

History of the Water Mist Project and CSM's involvement: Fighting Fires in Space with Water Mist



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Center for Space Resources
Colorado School of Mines, Golden, CO, USA

Apollo 1

January 27, 1967

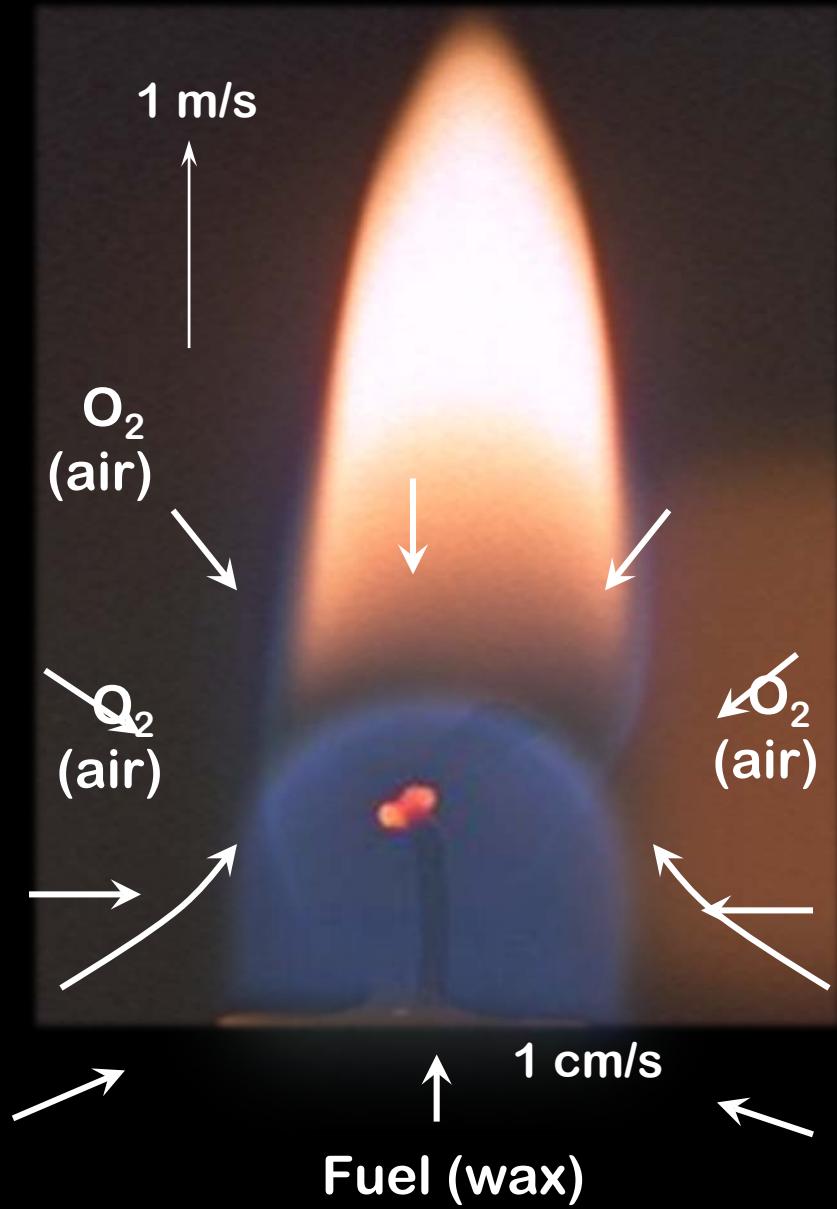


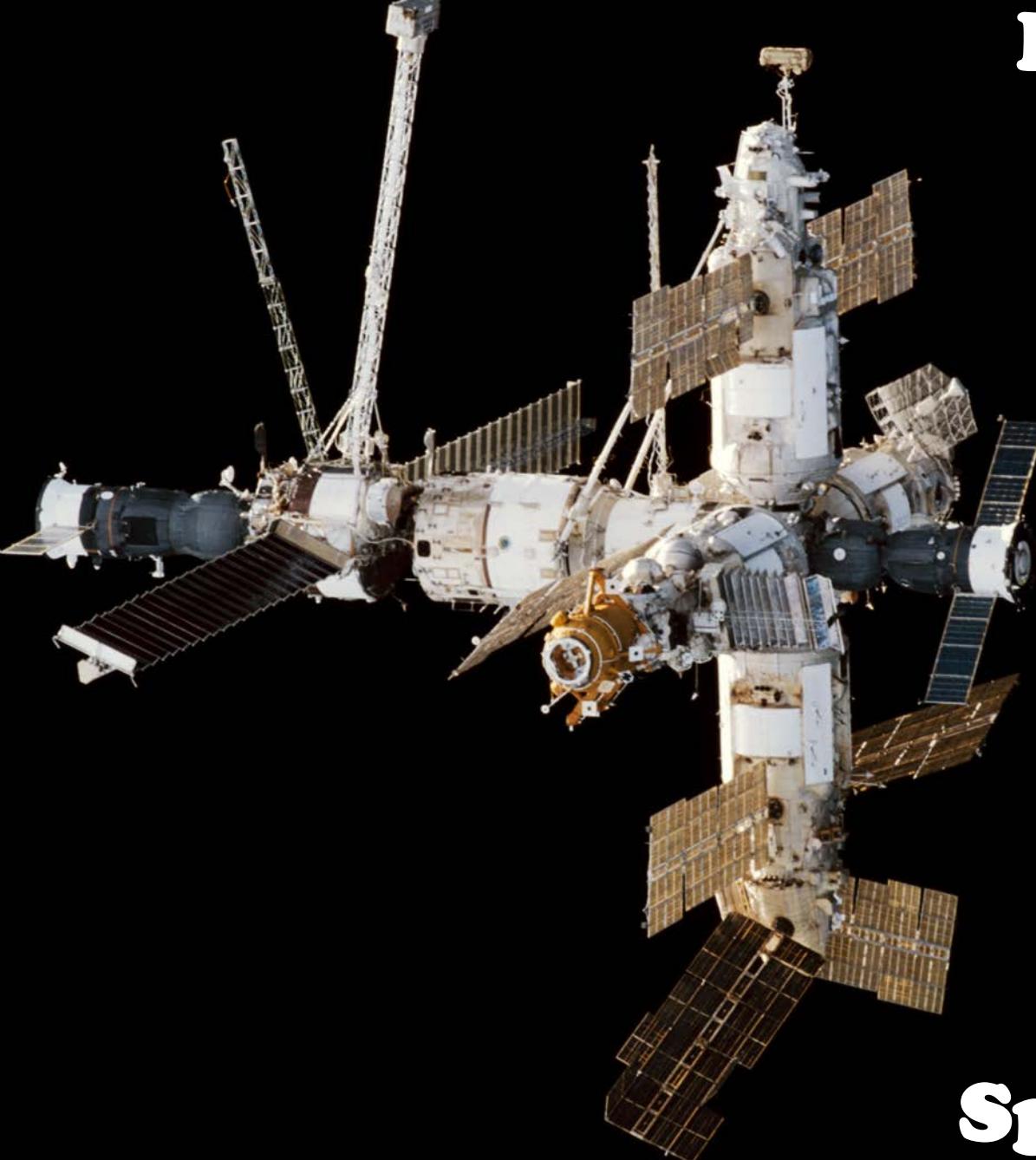
Lessons learned:

- * **Switch from 100% oxygen to air**
- * **Materials flammability**

1g (normal gravity)

μg (Weightlessness)

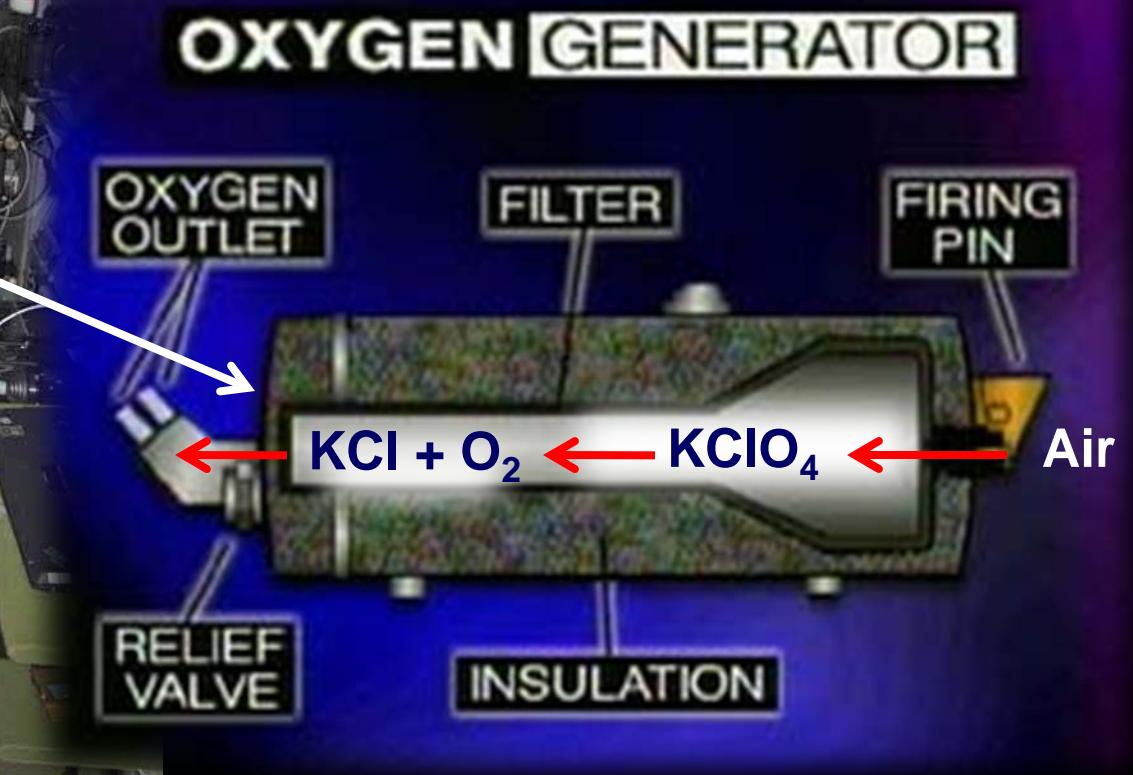
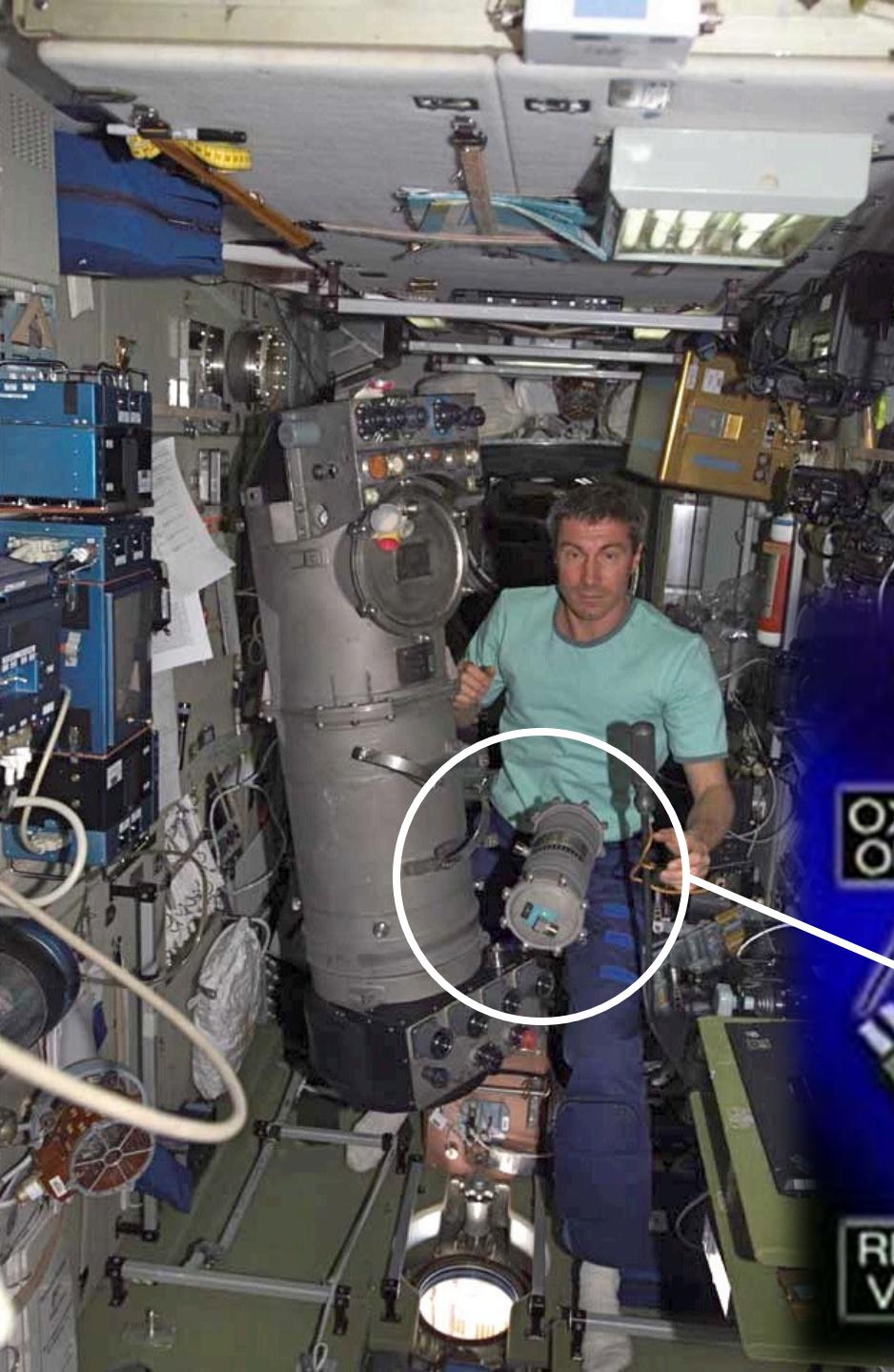




Feb 27, 1997

MIR
Space Station

Oxygen candle



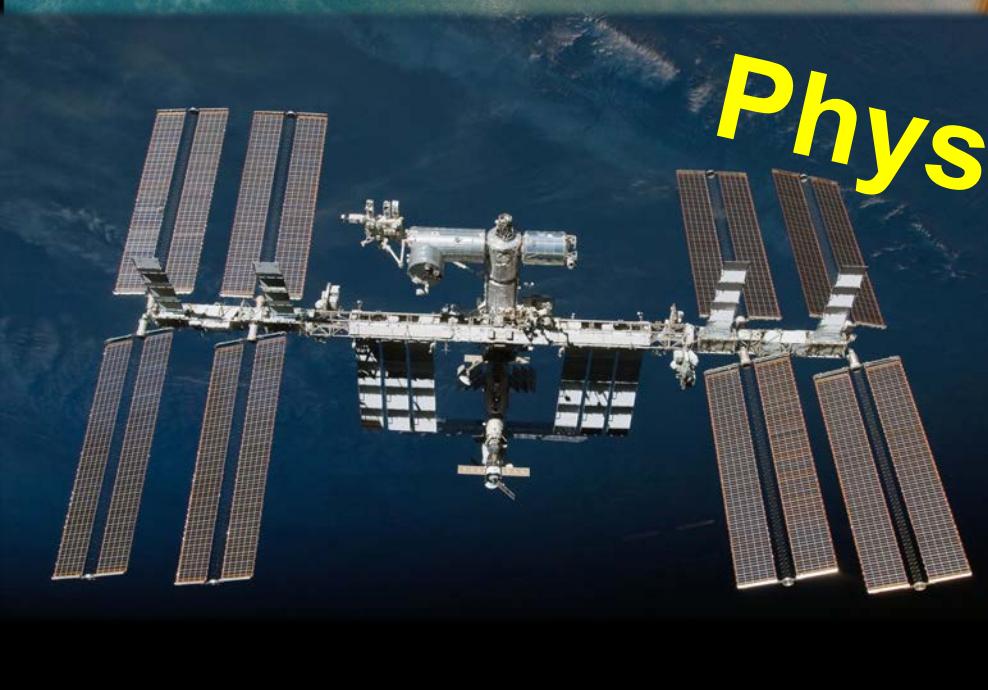


**Jerry Linenger
(US astronaut)**

Fire suppression in spacecraft



Halon 1301
(CF_3Br)



Physical



Motivation



**CF₃Br
(Halon)**



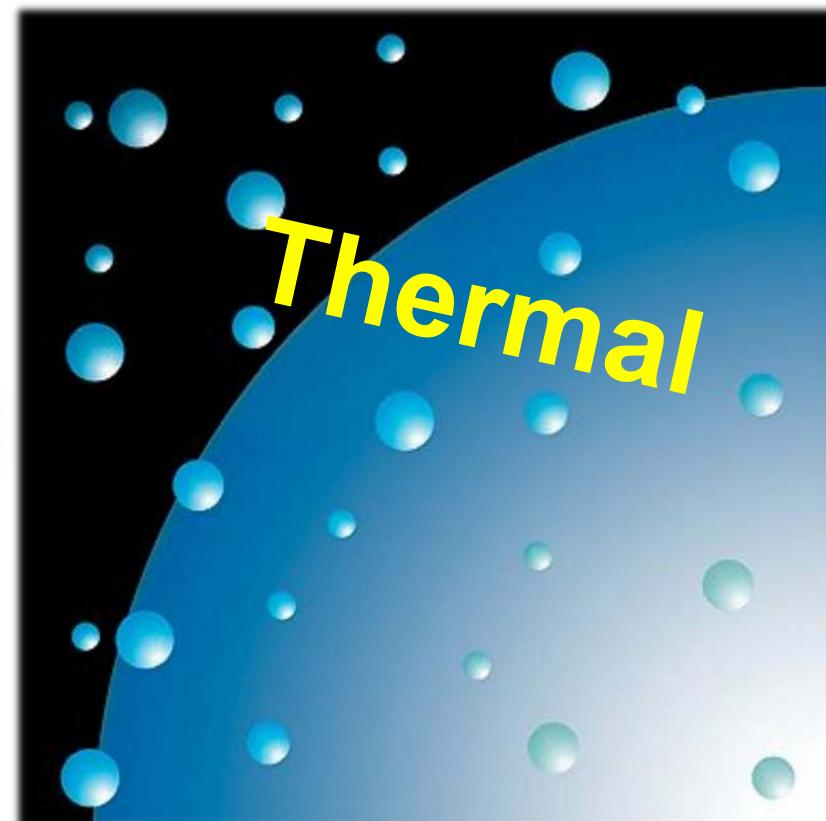
H₂O



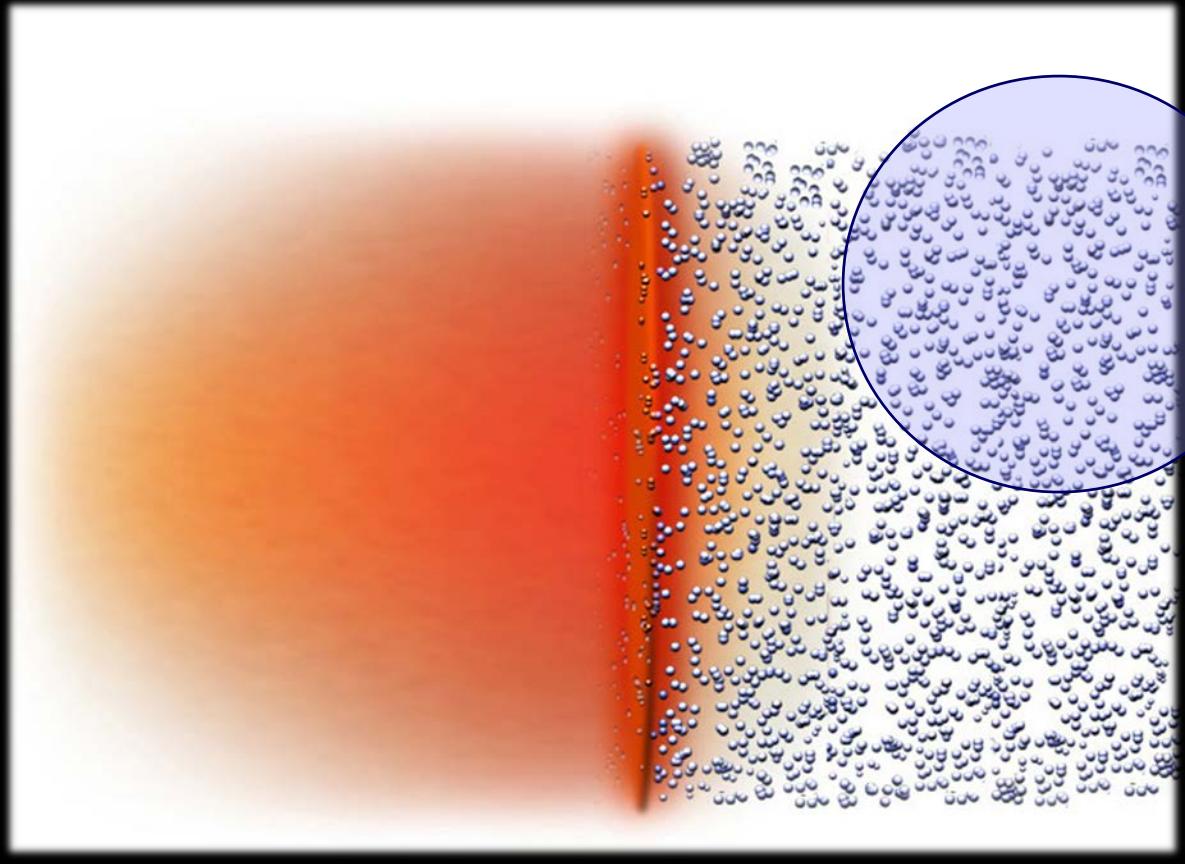
UNEP

**Montreal
Protocol
(1994)**

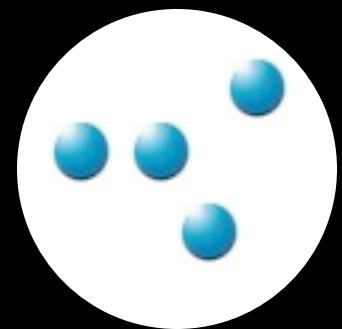
Water mist



Determine effect of:

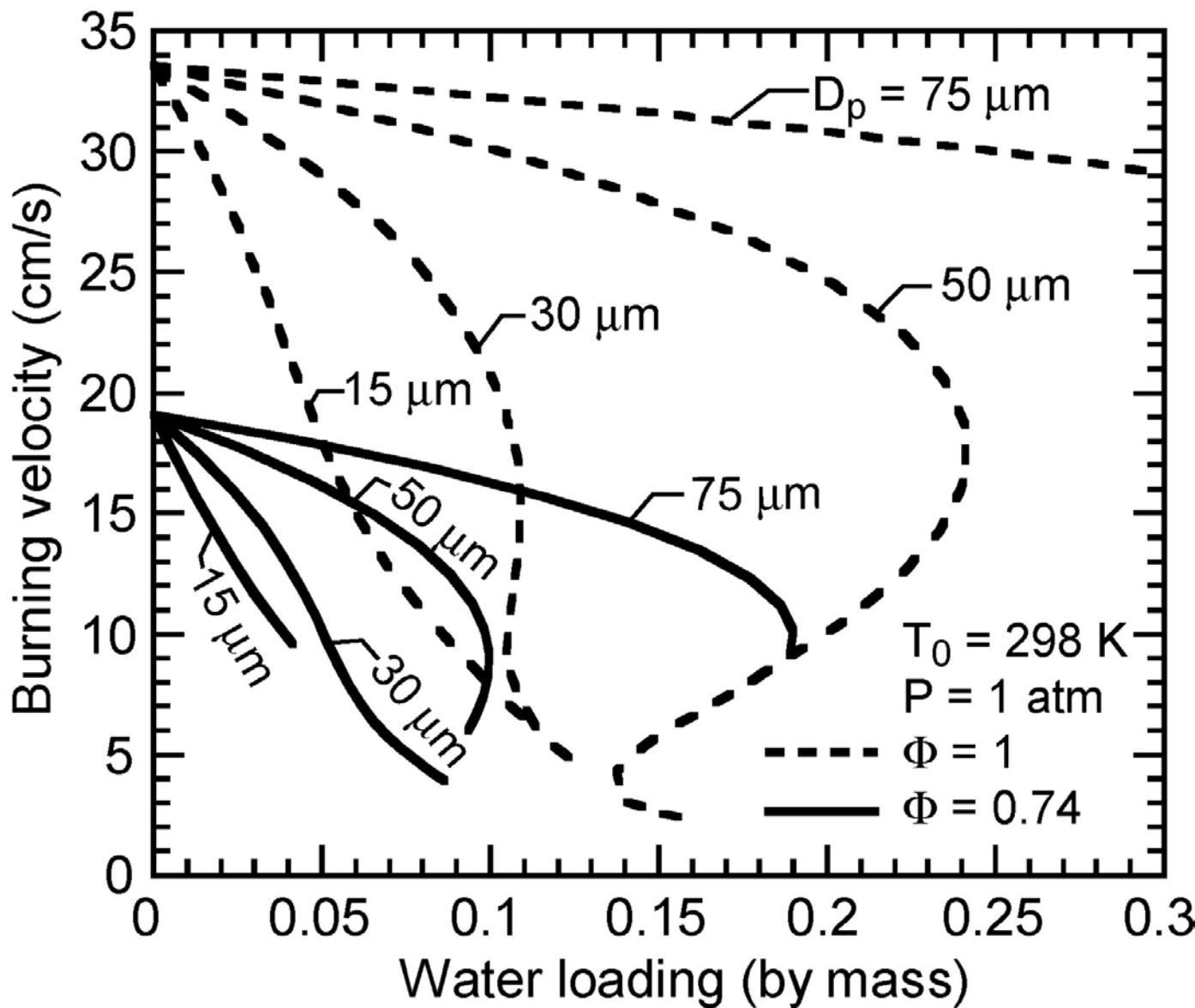


**Water
amount**

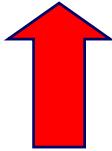


**Droplet
Size**

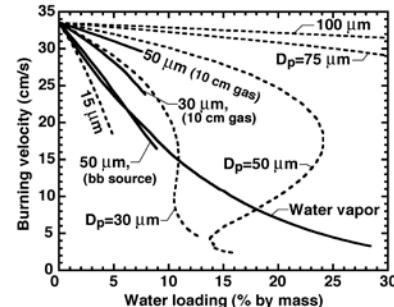
Numerical Model Results (CH_4 -air)



GROUND TESTING

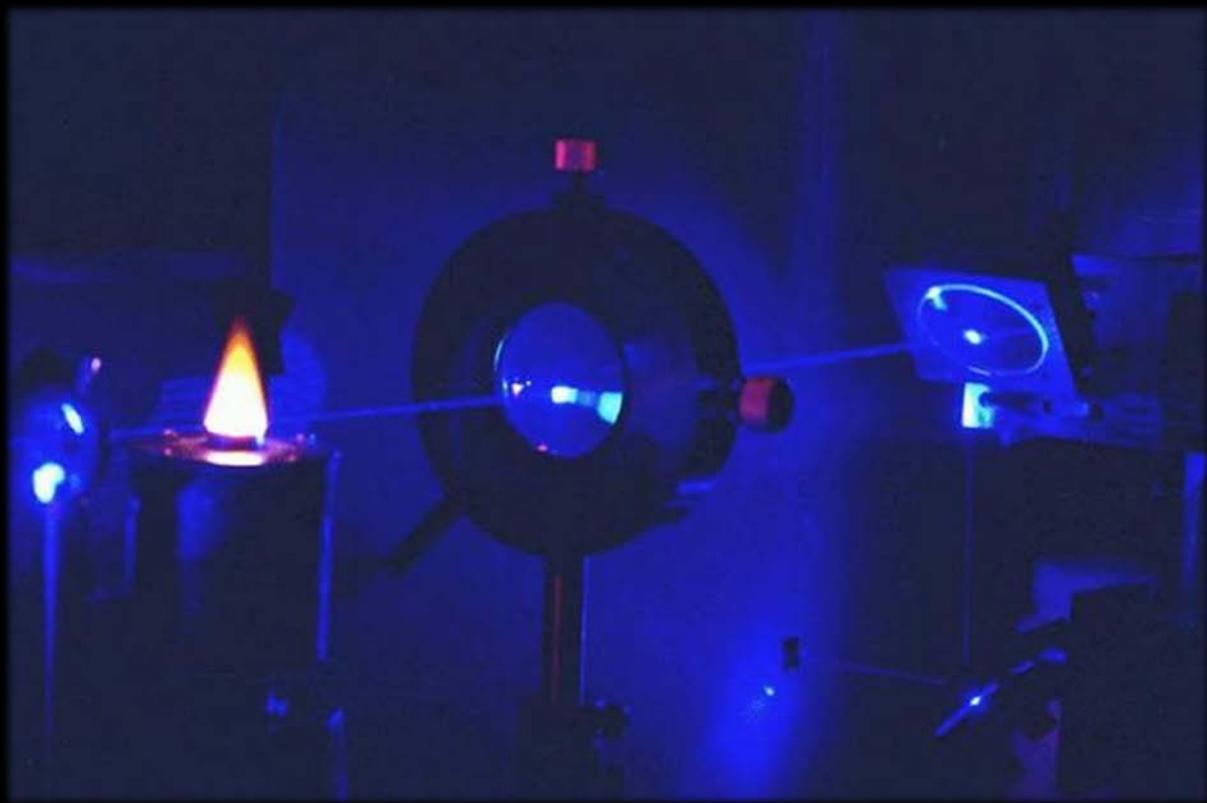


- OBJECTIVES
- MODELING PREDICTIONS
- REQUIREMENTS



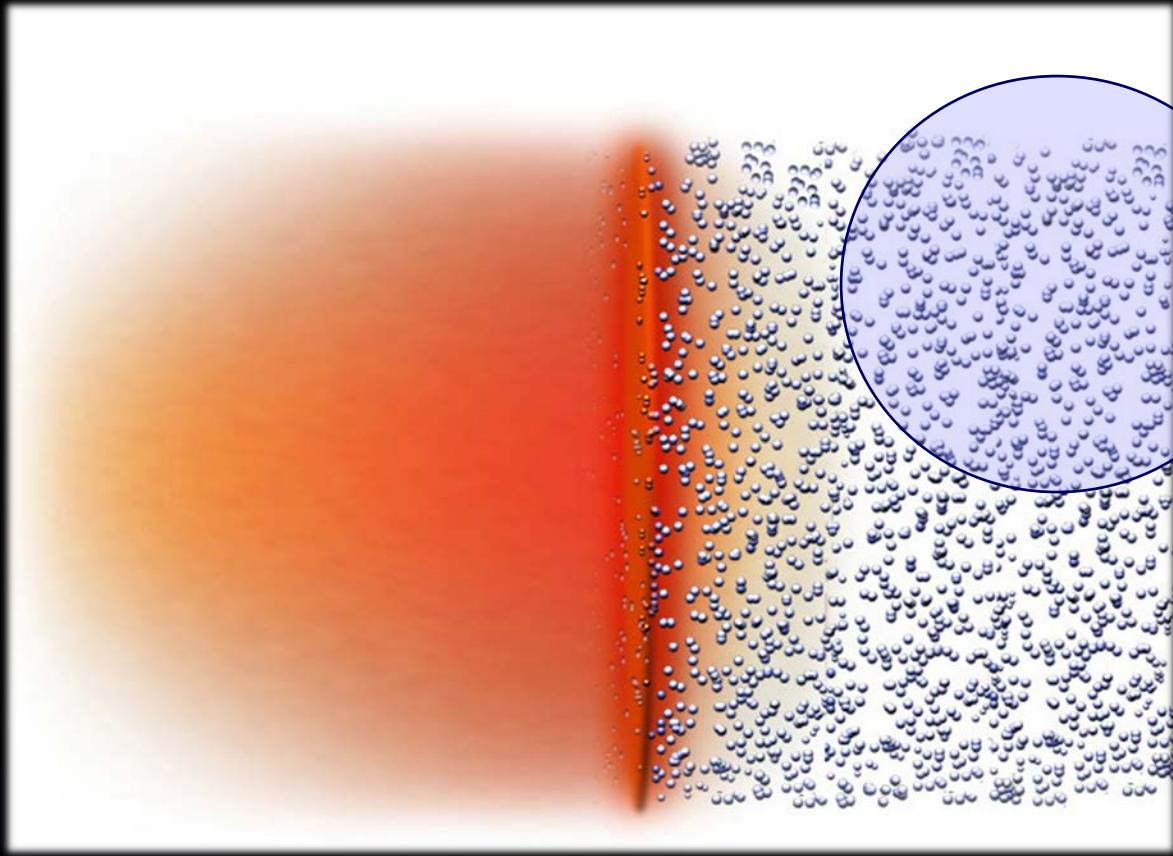
1997

GROUND TESTING

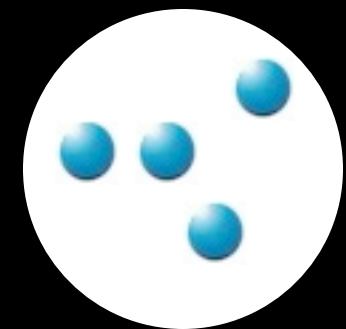


No gravity?

Determine effect of:

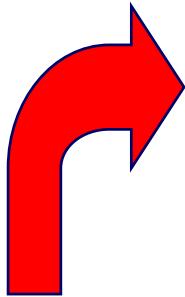


**Water
amount**

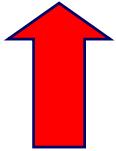


**Droplet
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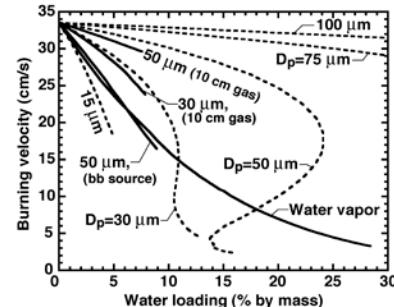
FREE FALL TESTS (GROUND FACILITIES)



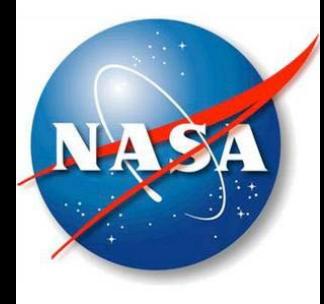
GROUND TESTING



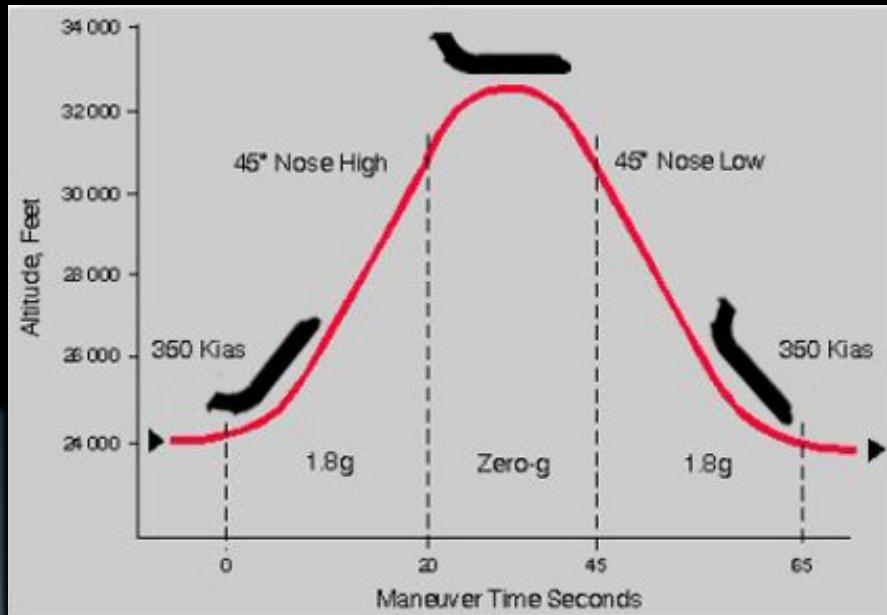
- OBJECTIVES
- MODELING PREDICTIONS
- REQUIREMENTS



Drop towers



Parabolic-trajectory airplane



$$x_f = (1/2) g t_f^2$$

For $t=25 \text{ sec}$

Height $\approx 3125 \text{ m} !$



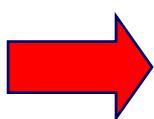
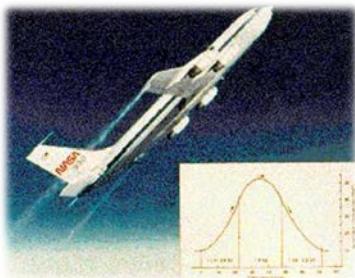
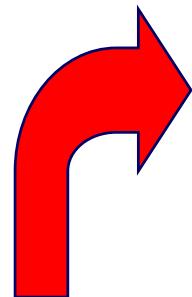
Free fall around Earth

$t_f = Days !$



FLIGHT HARDWARE DESIGN AND DEVELOPMENT

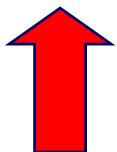
LOW-GRAVITY
GROUND
FACILITIES



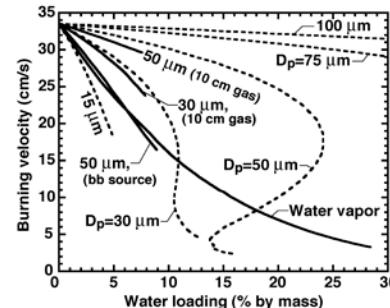
SPACECRAFT
INTERFACE



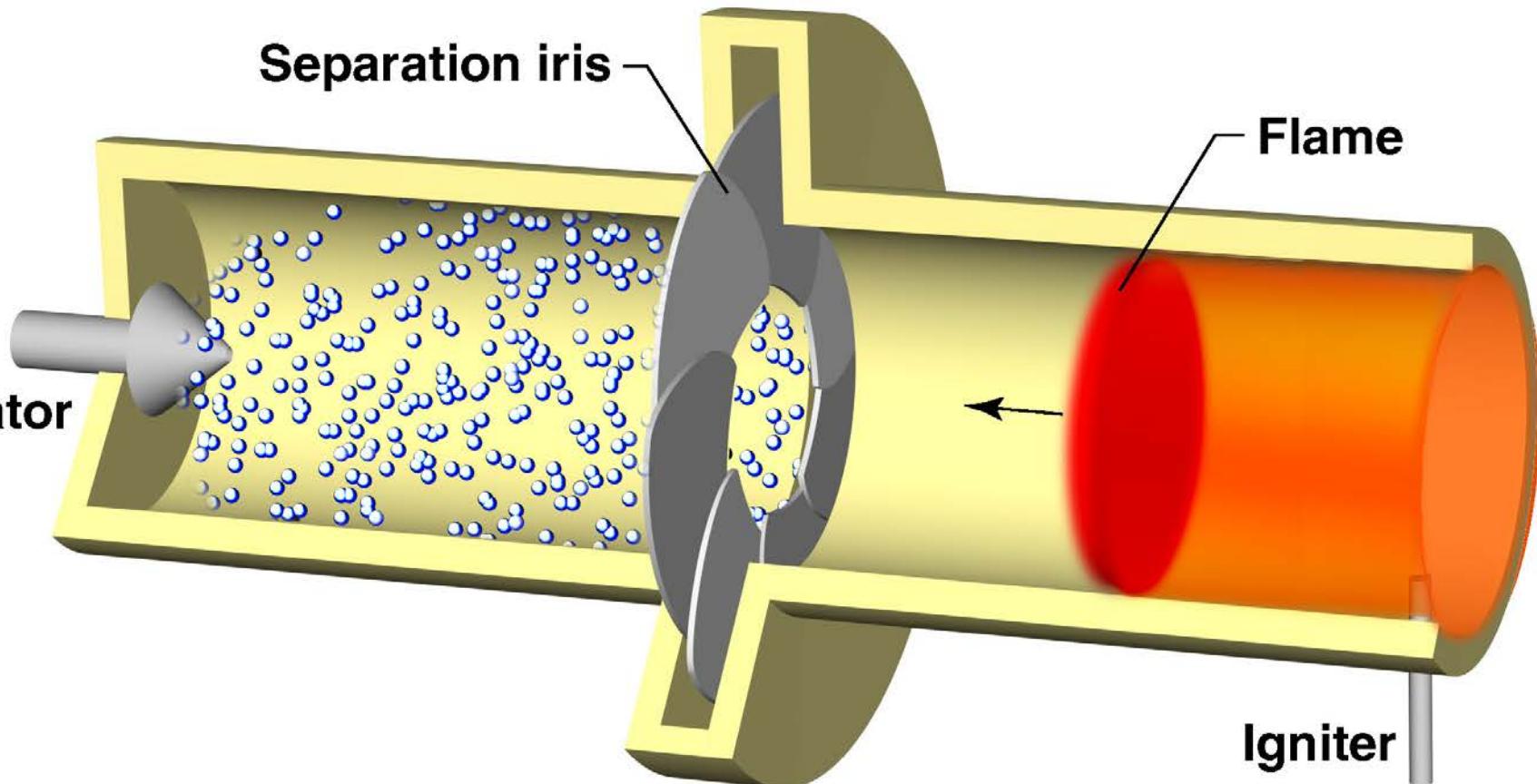
GROUND TESTING



- OBJECTIVES
- MODELING PREDICTIONS
- REQUIREMENTS



Design

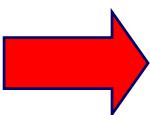
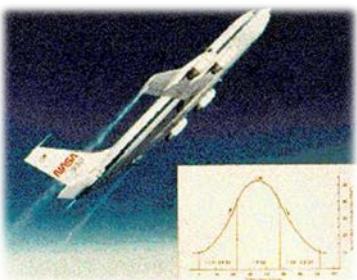
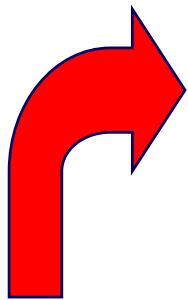


Fabrication & Assembly



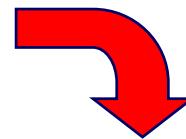
**Final Experimental
Mounting Structure (EMS)**

LOW-GRAVITY GROUND FACILITIES



FLIGHT DESIGN AND DEVELOPMENT

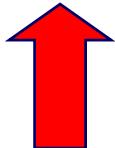
- Design
- Parts selection
- Models and trainers
- Safety documentation
- Fabrication
- Assembly
- Testing
- Environmental tests
- Simulation



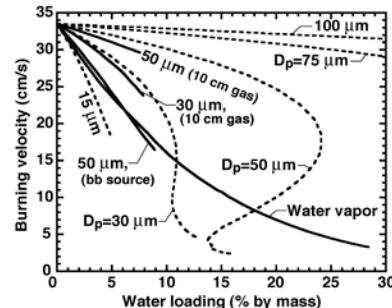
SPACECRAFT INTEGRATION



GROUND TESTING



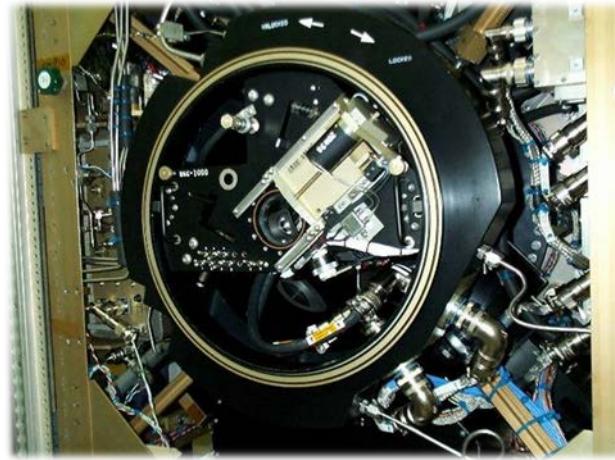
- OBJECTIVES
- MODELING PREDICTIONS
- REQUIREMENTS



Hardware Integration



Mist EMS



Mist on CM-2 vessel



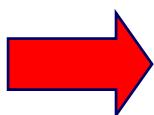
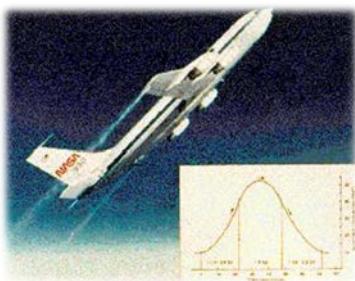
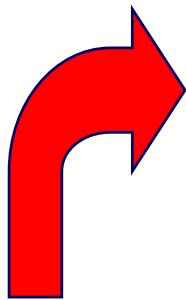
*CM-2 on
SPACEHAB racks*

*CM-2 on
SPACEHAB*



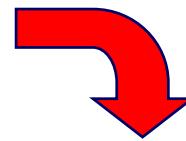
SPACEHAB on Shuttle

LOW-GRAVITY GROUND FACILITIES

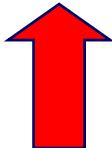


FLIGHT DESIGN AND DEVELOPMENT

- Design
- Parts selection
- Models and trainers
- Safety documentation
- Fabrication
- Assembly
- Testing
- Environmental tests
- Simulation



GROUND TESTING



FLIGHT



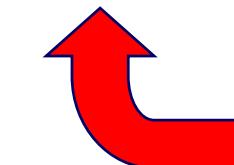
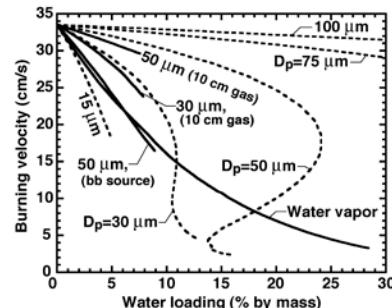
2003

SPACECRAFT INTEGRATION

- CM2, SPACEHAB
- Shuttle
- Integration
- Crew training
- Simulation



1997



- OBJECTIVES
- MODELING PREDICTIONS
- REQUIREMENTS

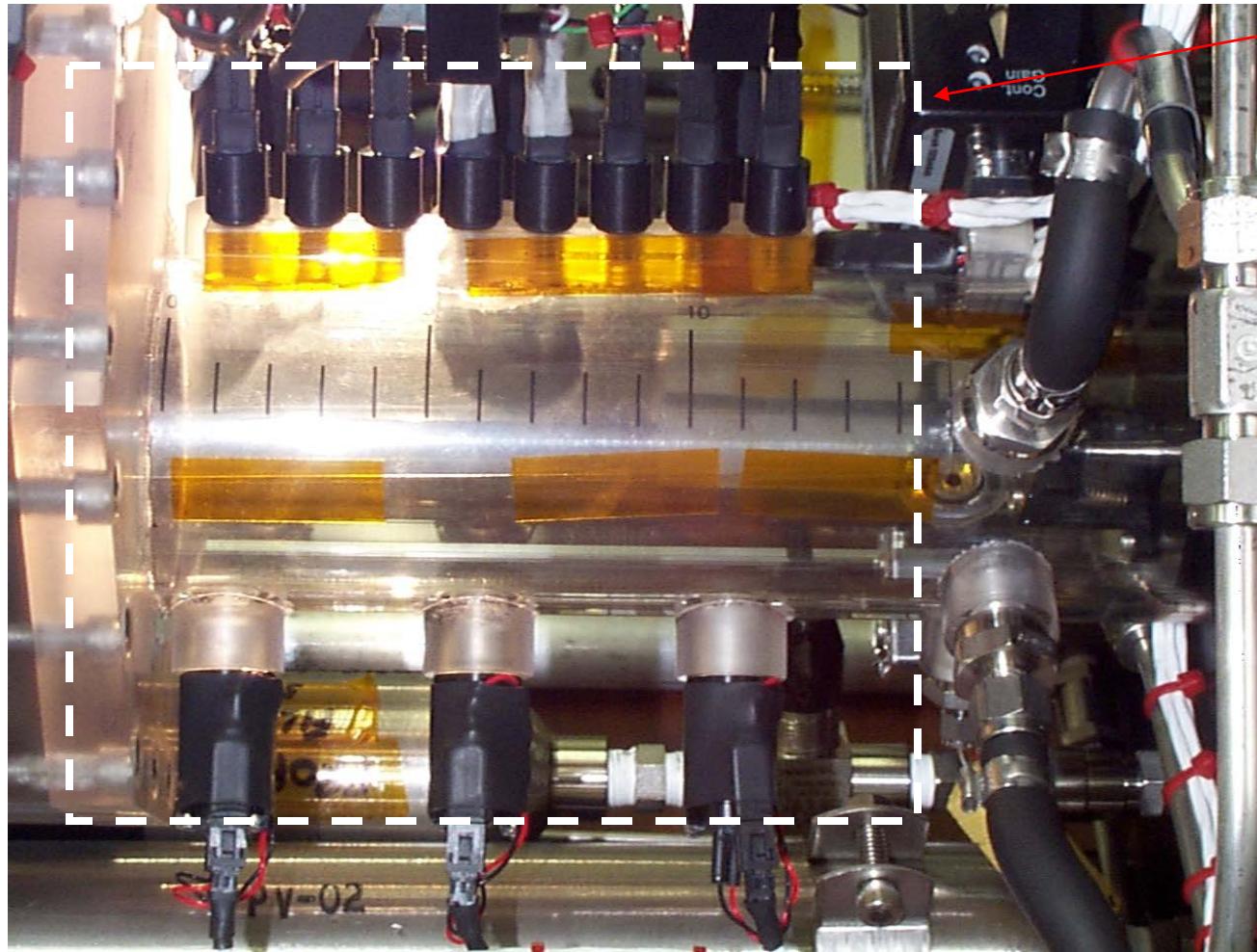
STS-107 Mission (January 16, 2003)



In Orbit ...

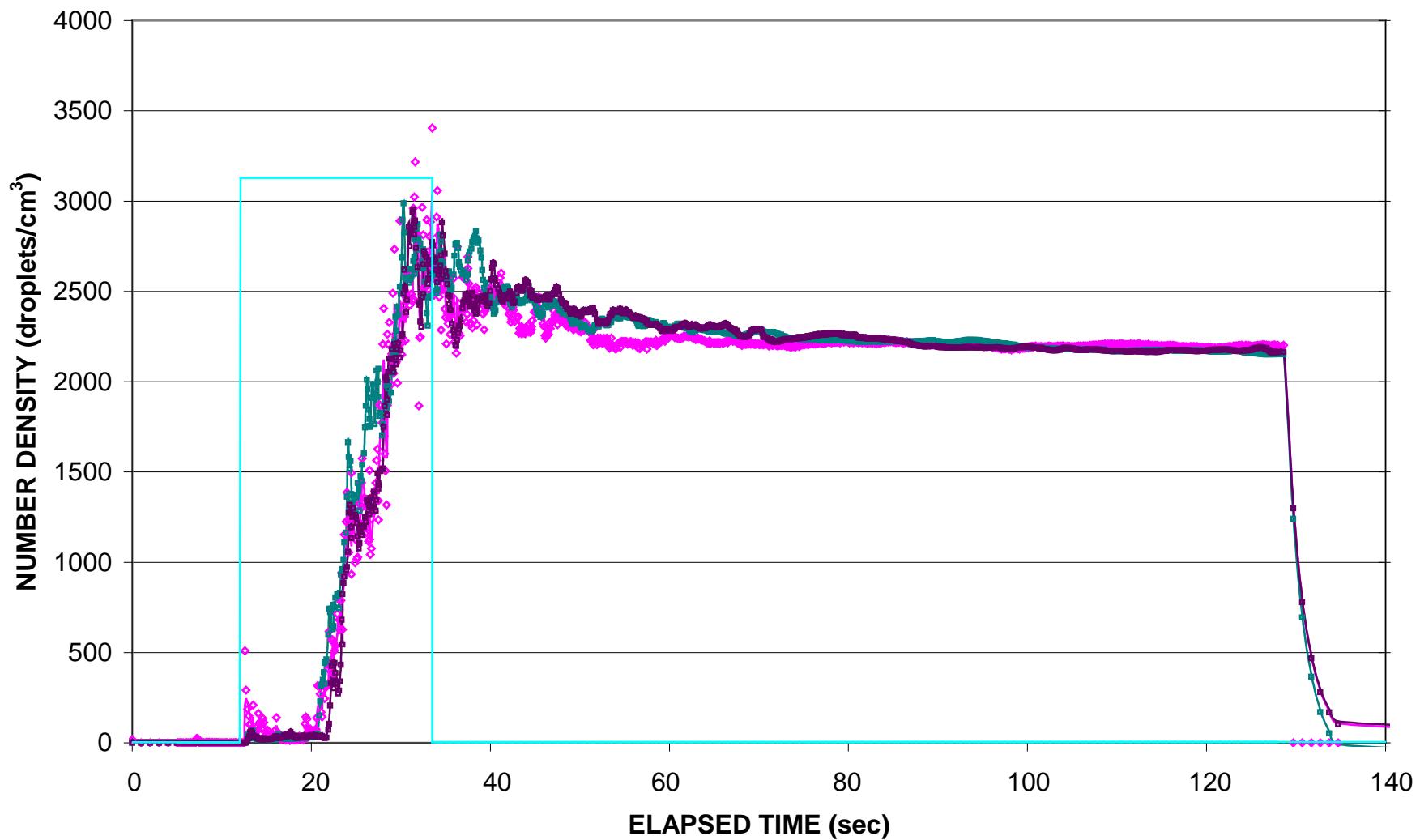


Wet Section of Flame Tube

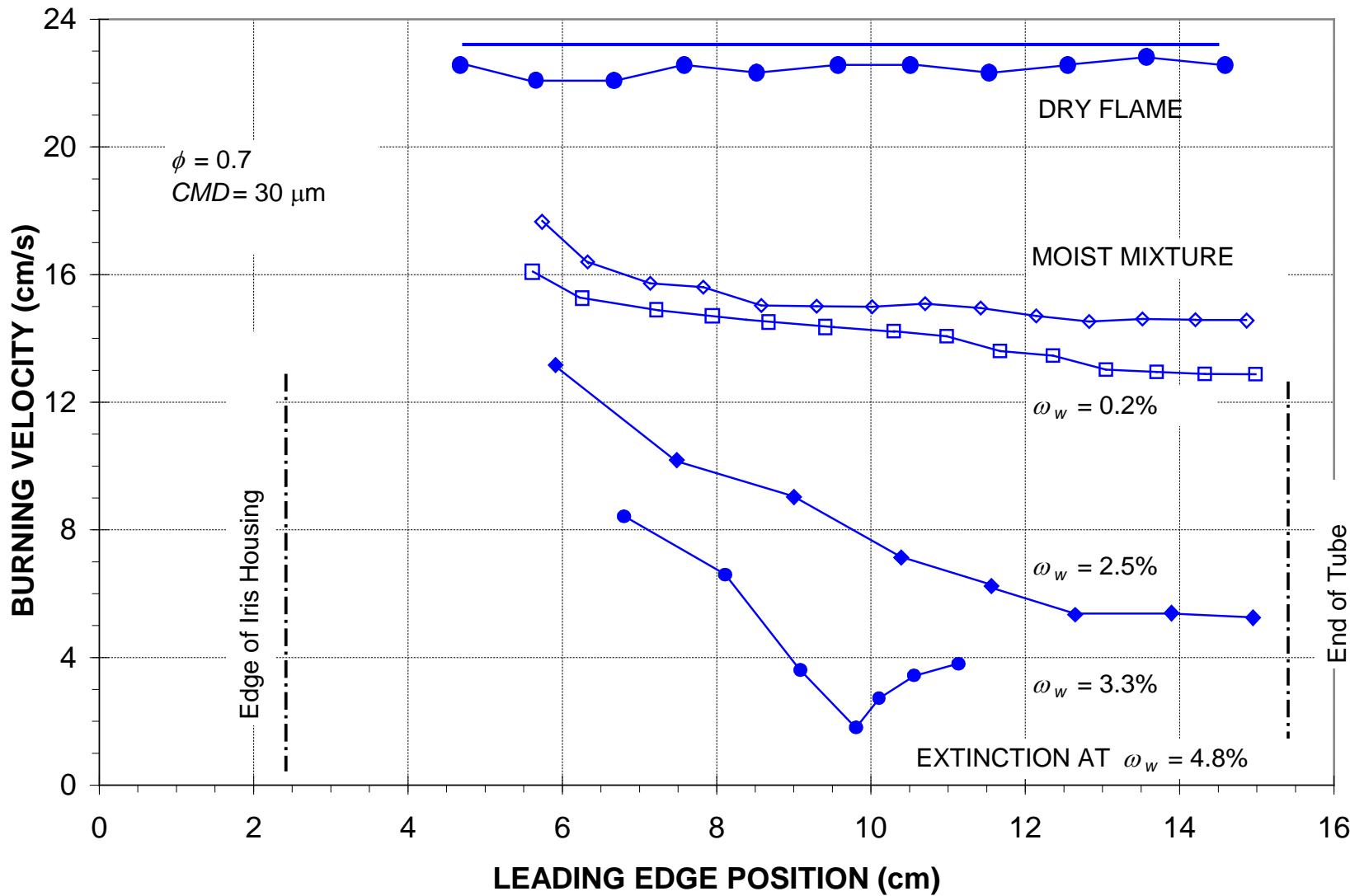


Lasers (3)

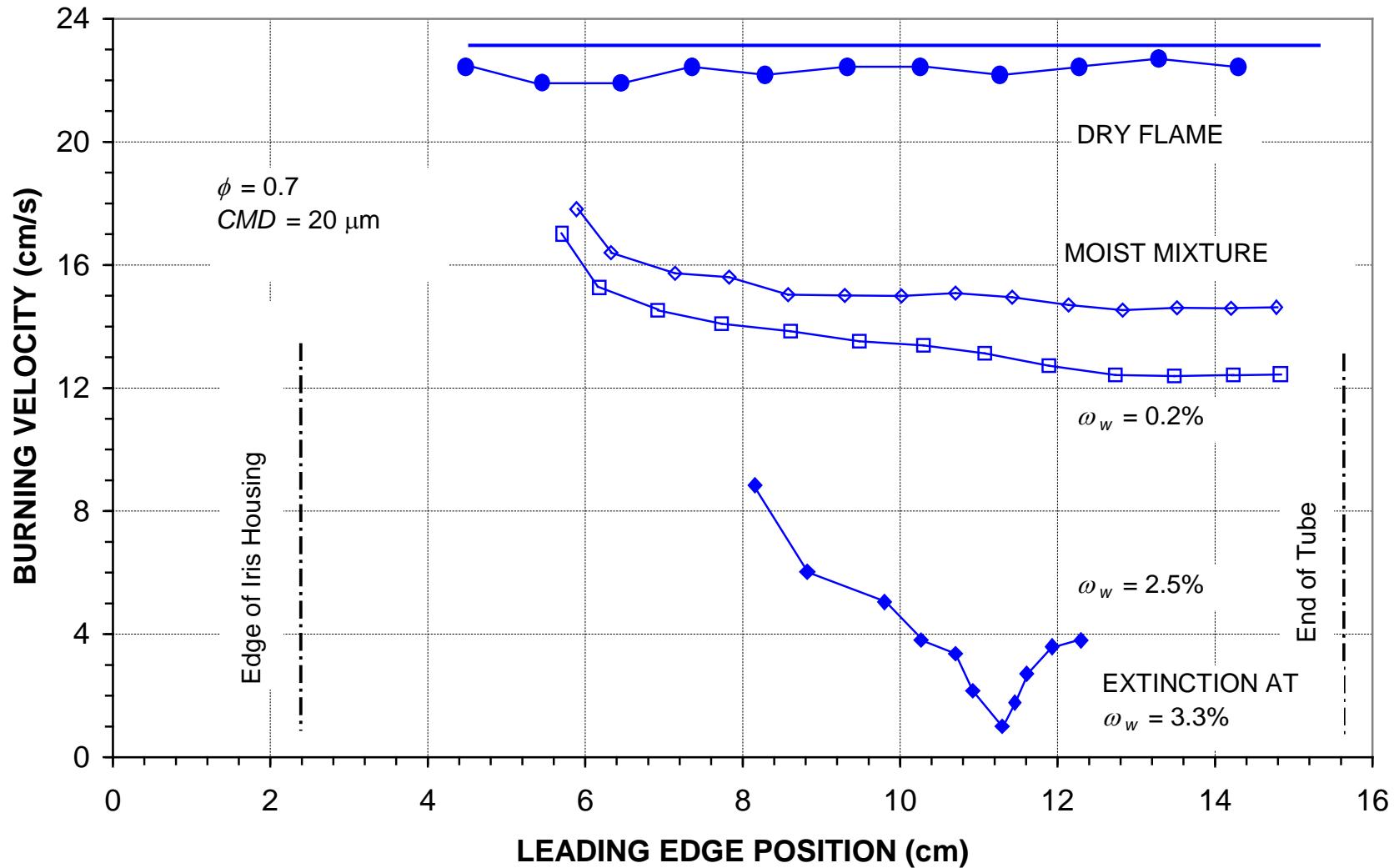
Water mist behavior in microgravity



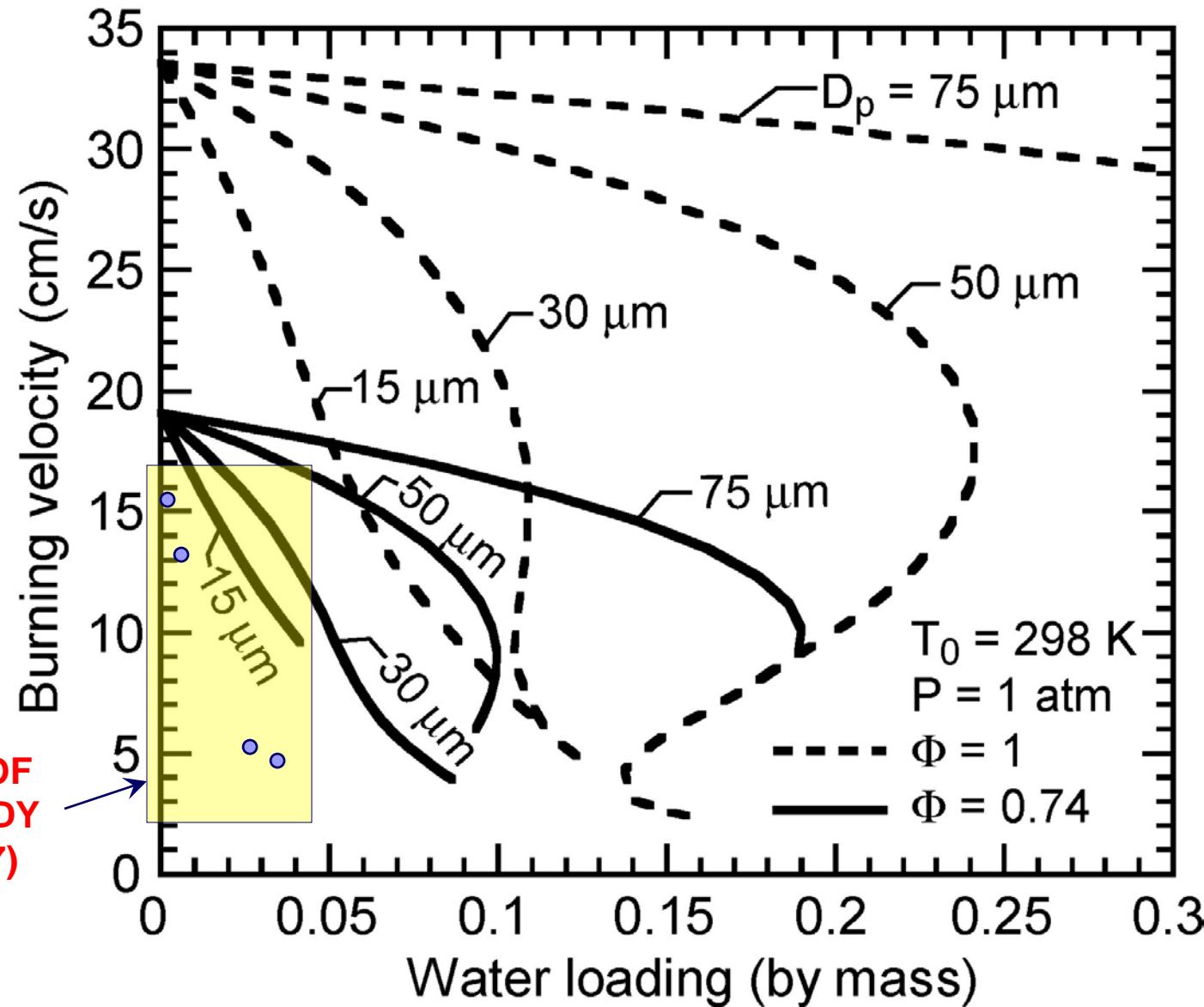
Results (Water loading effects I)



Results (Water loading effects II)



Numerical-Experimental Comparison



February 1, 2003

WFAA

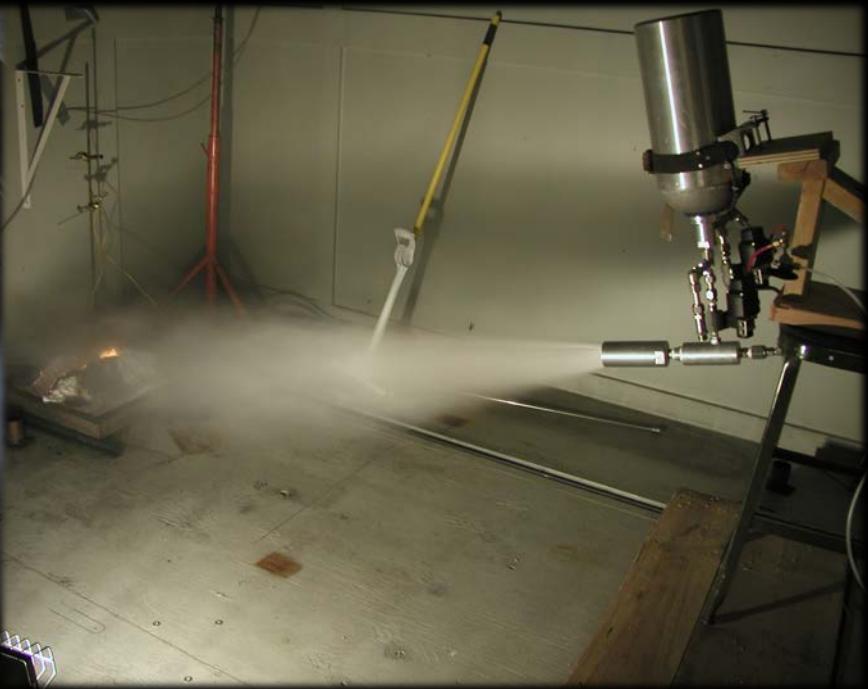
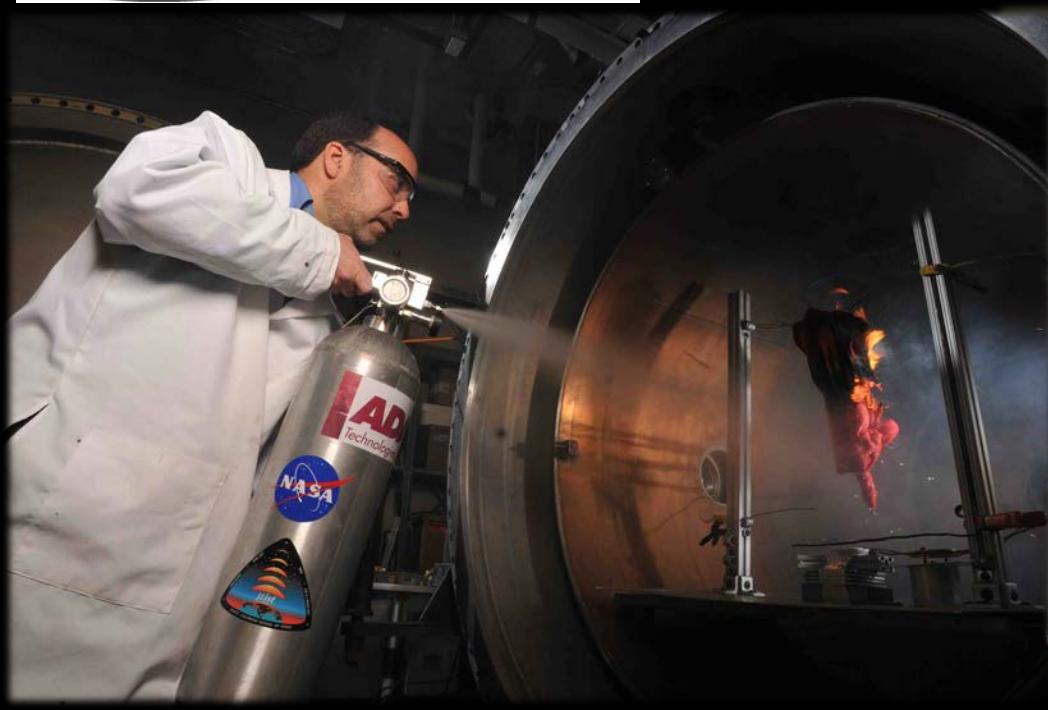
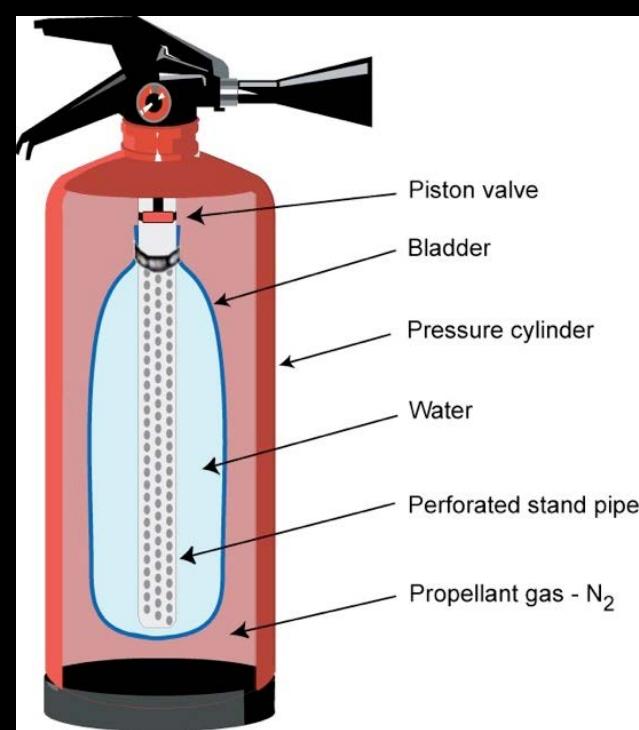
BREAKING NEWS

CNN

OFFICIAL AT JOHNSON SPACE
CENTER: "SHUTTLE LOST"

2003 – 2011 ...





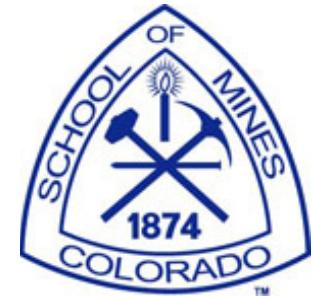
2011 – 2016



wyle

ADA
Technologies, Inc.

The logo for Flexial Welded Bellows. It features the word "FLEXIAL" in large blue letters inside a yellow swoosh, with "WELDED BELLOWS" in smaller blue letters below it.



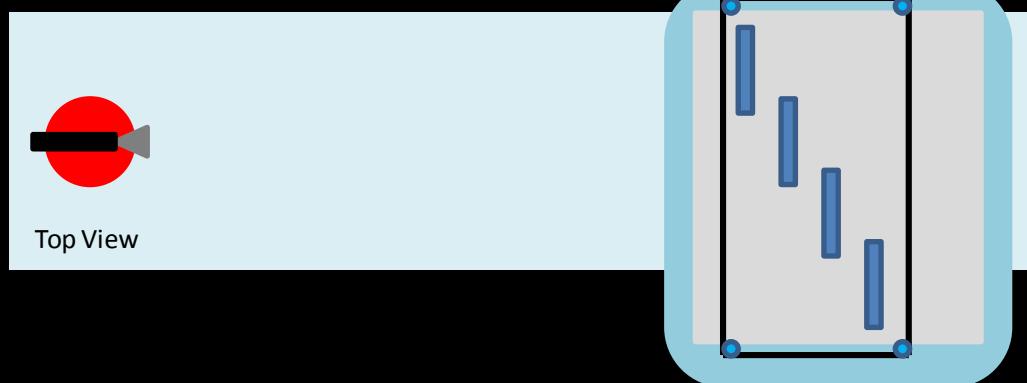
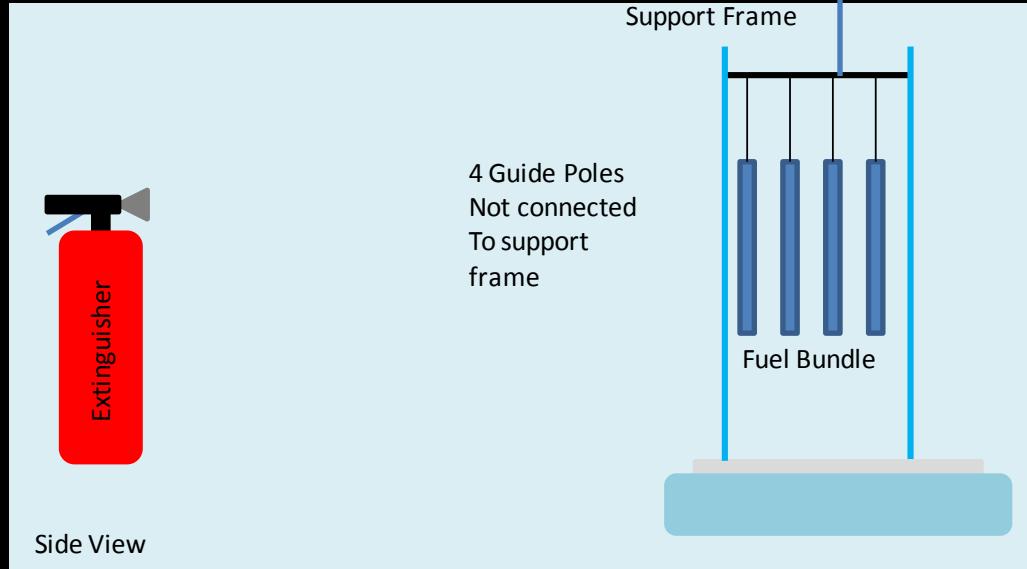
Water Mist Portable Fire Extinguisher (PFE)

Engineering Development Unit (EDU)

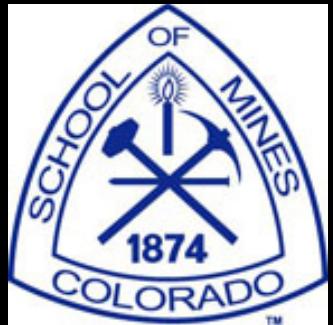


ISS Fire Scenarios (I) – Open Cabin

* Test Configuration

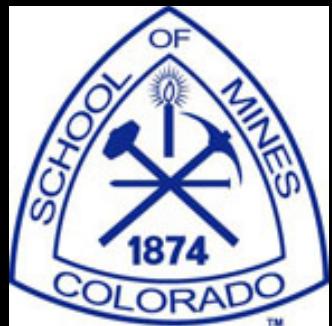


ISS Fire Scenarios (I) – Open Cabin



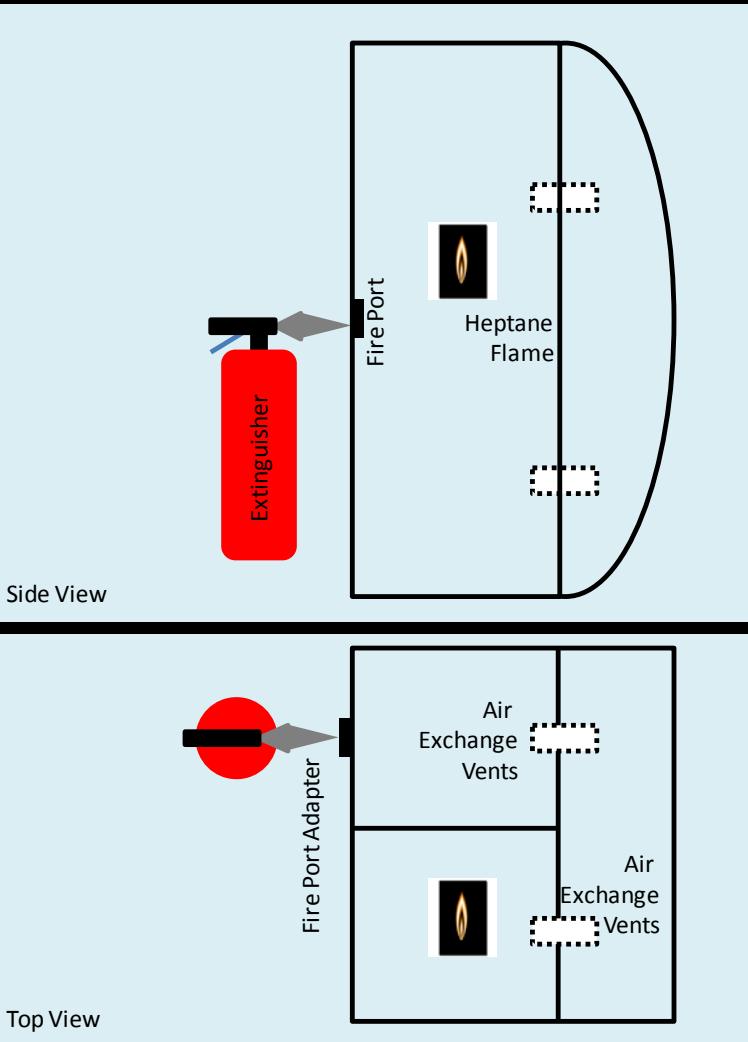
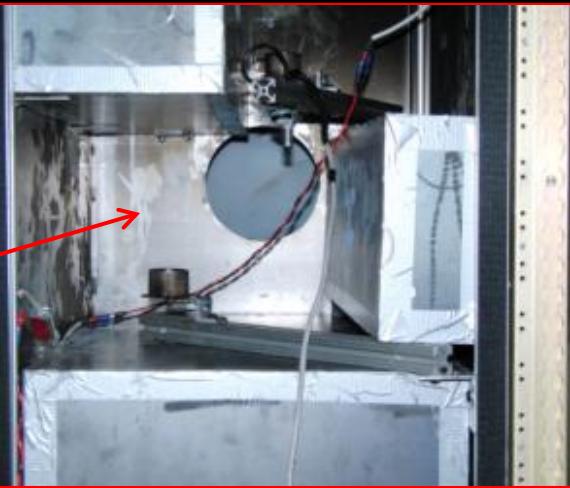
ISS Fire Scenarios (I) – Open Cabin Tests

VIDEO



ISS Fire Scenarios (II) – Rack

* Test Configuration



Glenn
Research
Center

ADA
Technologies, Inc.

ISS Fire Scenarios (II) – Rack Tests

VIDEO



Glenn
Research
Center



ISS Fire Scenarios (III) – Stored energy: battery

* Test Configuration

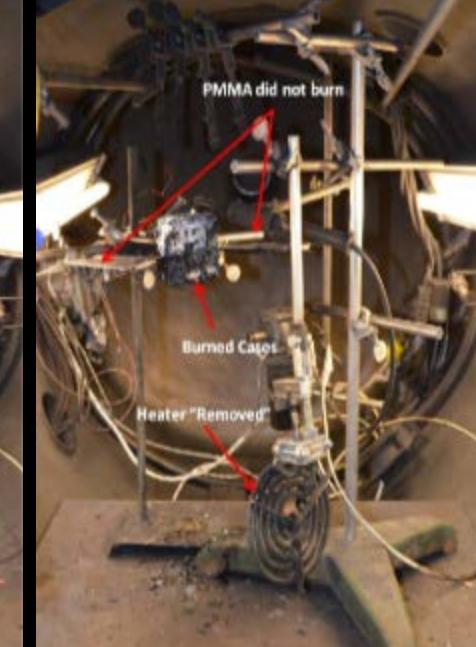
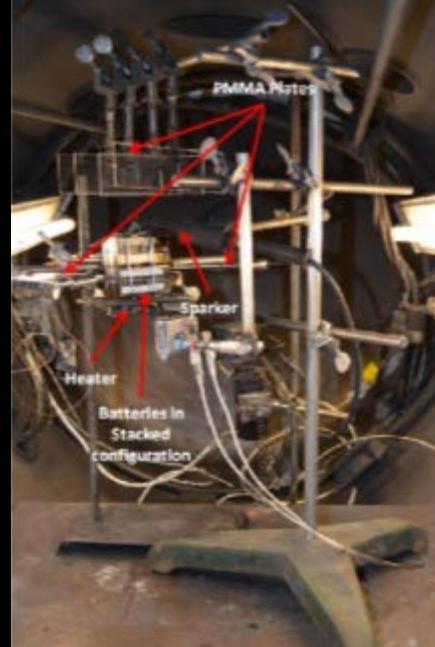
Battery Toxicity Evaluation



Battery Testing with Witness Plate



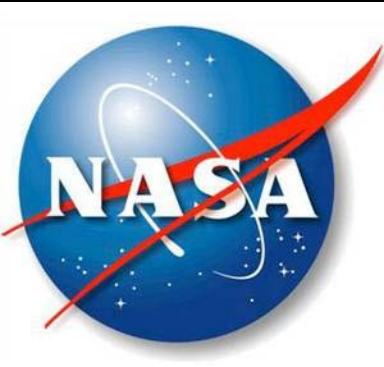
Pre and Post Test Configuration



White
Sands
Test
Facility

ISS Fire Scenarios (III) – Stored energy: battery

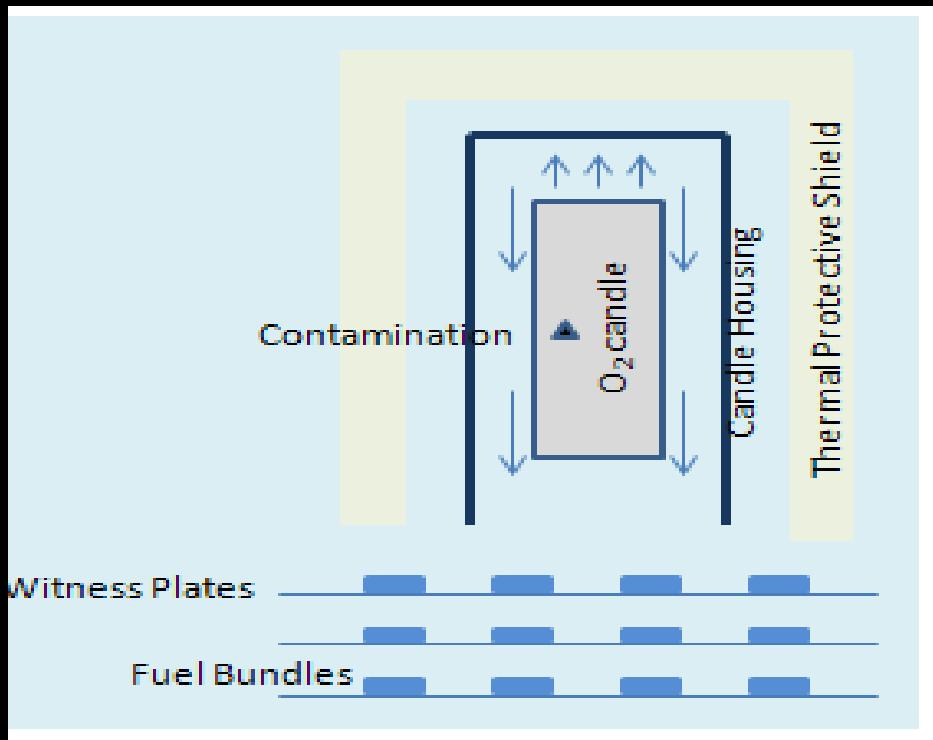
VIDEO



White
Sands
Test
Facility

ISS Fire Scenarios (IV) – Stored energy: O₂ candle

* Test Configuration



**White
Sands
Test
Facility**

ISS Fire Scenarios (IV) – Stored energy: O₂ candle

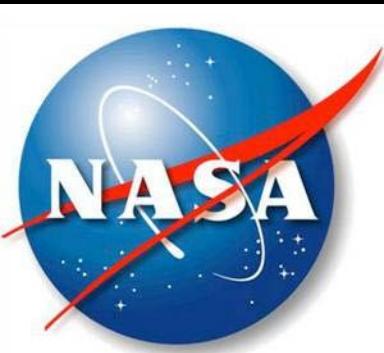
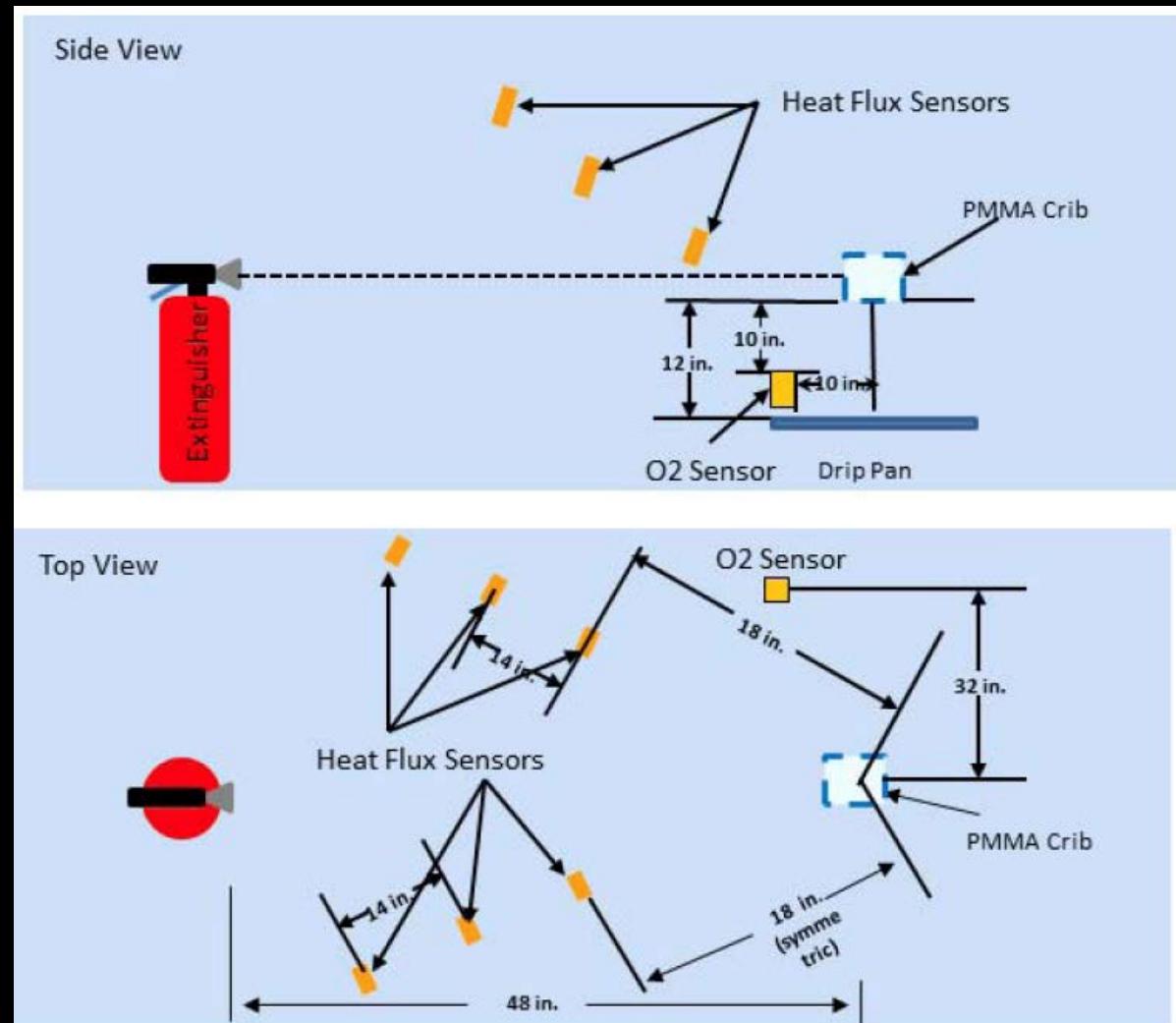
VIDEO



White
Sands
Test
Facility

ISS Fire Scenarios (V) – Elevated O₂ content

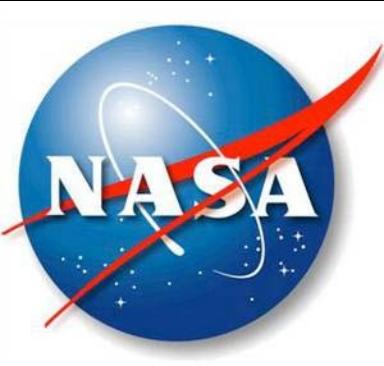
* Test Configuration



White
Sands
Test
Facility

ISS Fire Scenarios (V) – Elevated O₂ content

VIDEO



**White
Sands
Test
Facility**

Ready for launch ...



Delivery of first 2 PFEs (Cygnus OA-4 mission)



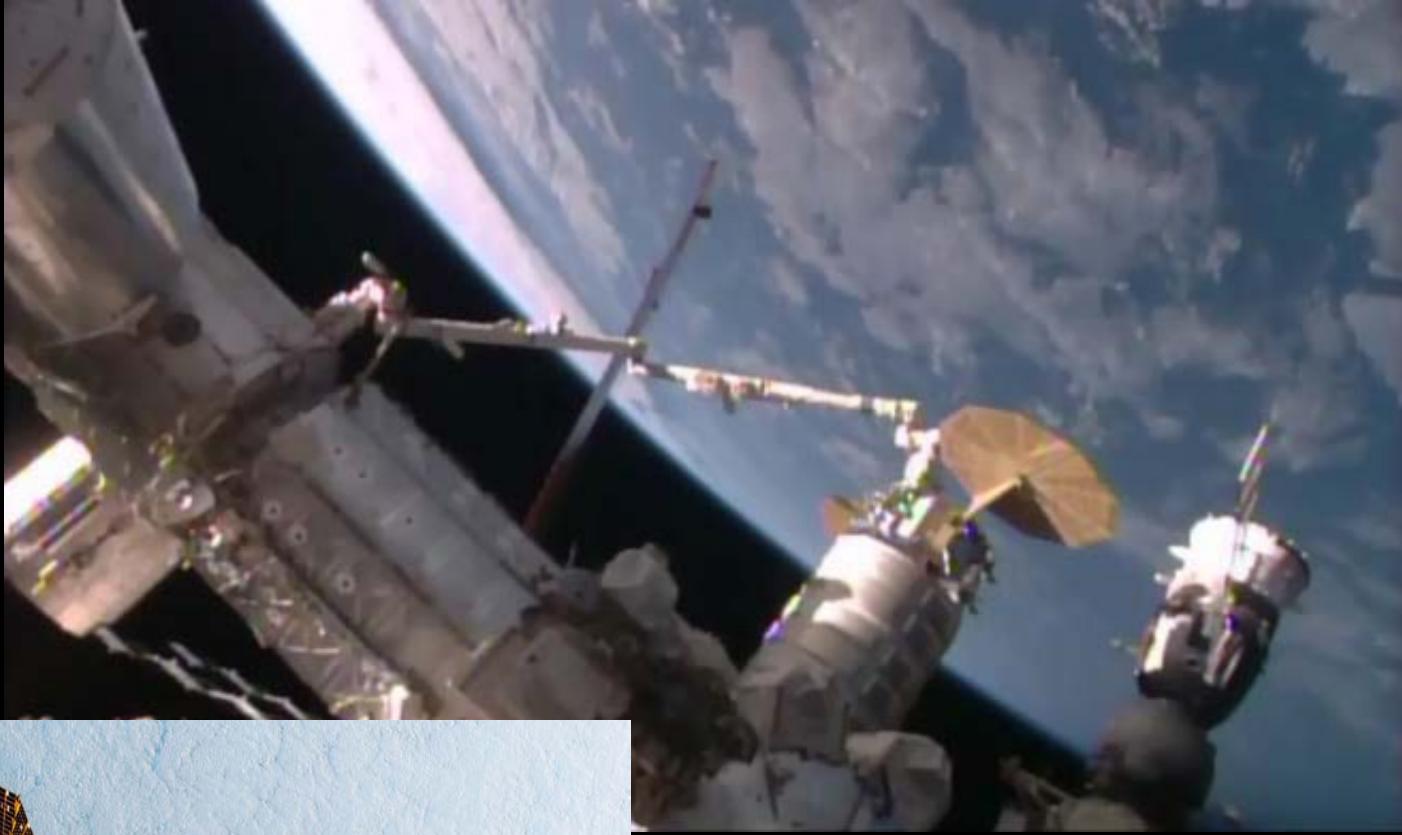
First PFEs delivery (Atlas V launch, 12/06/15)



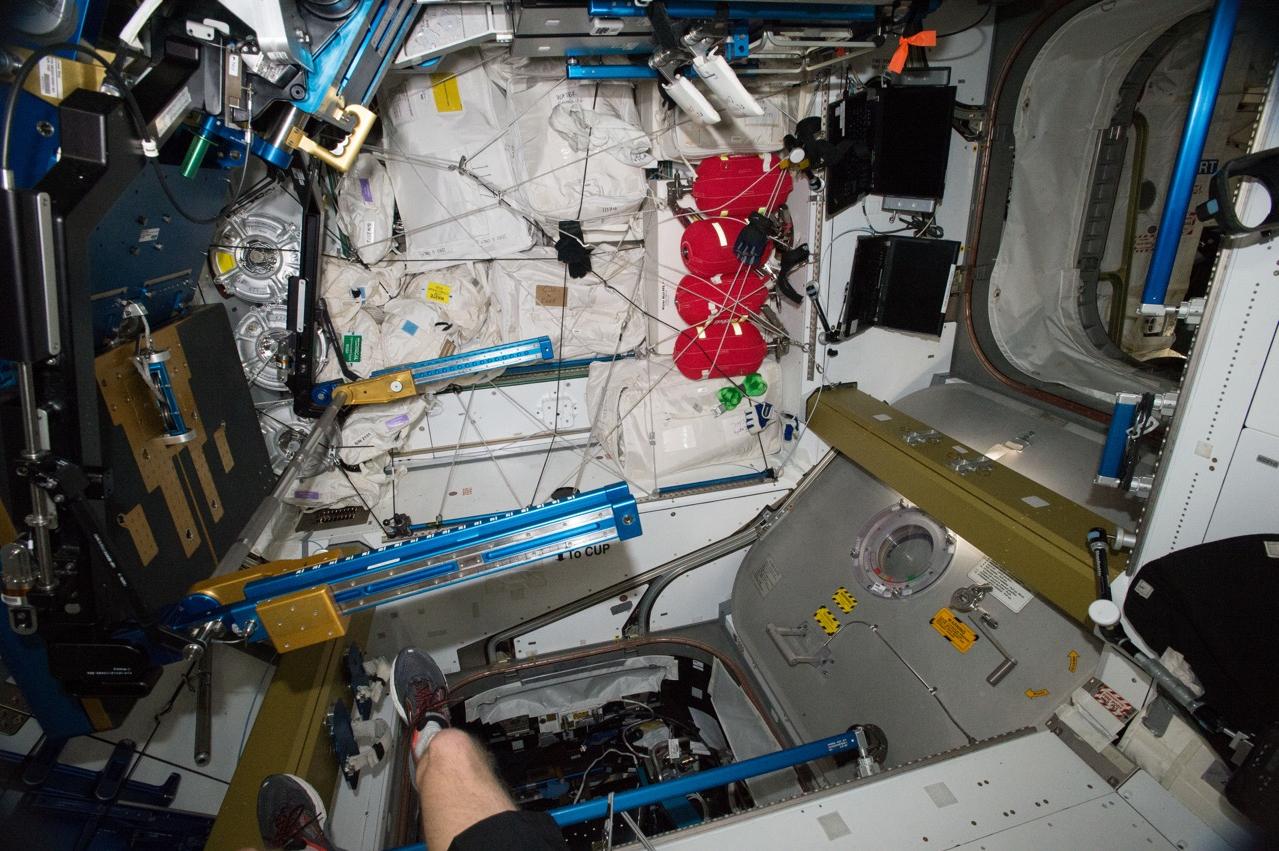
(Atlas V launch, 12/06/15)



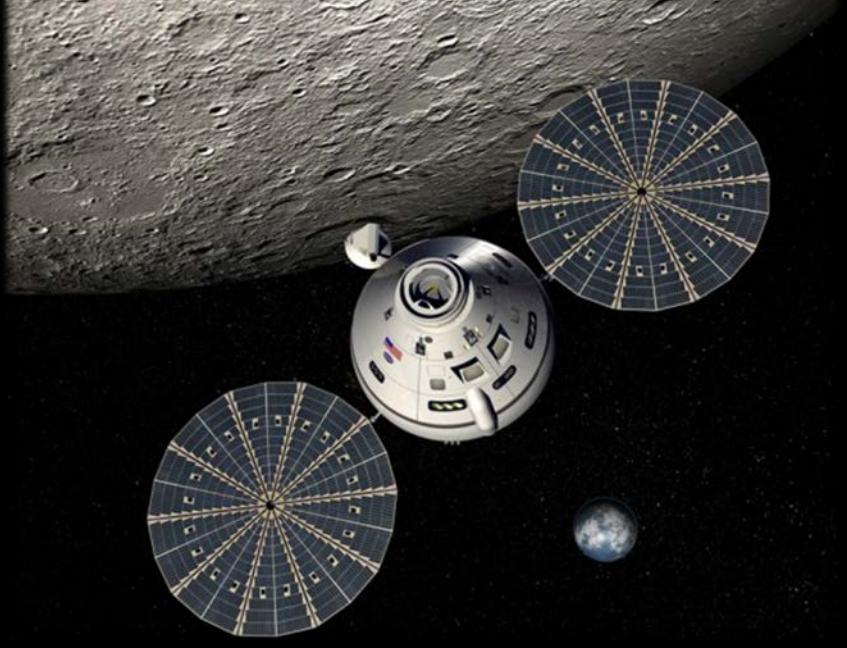
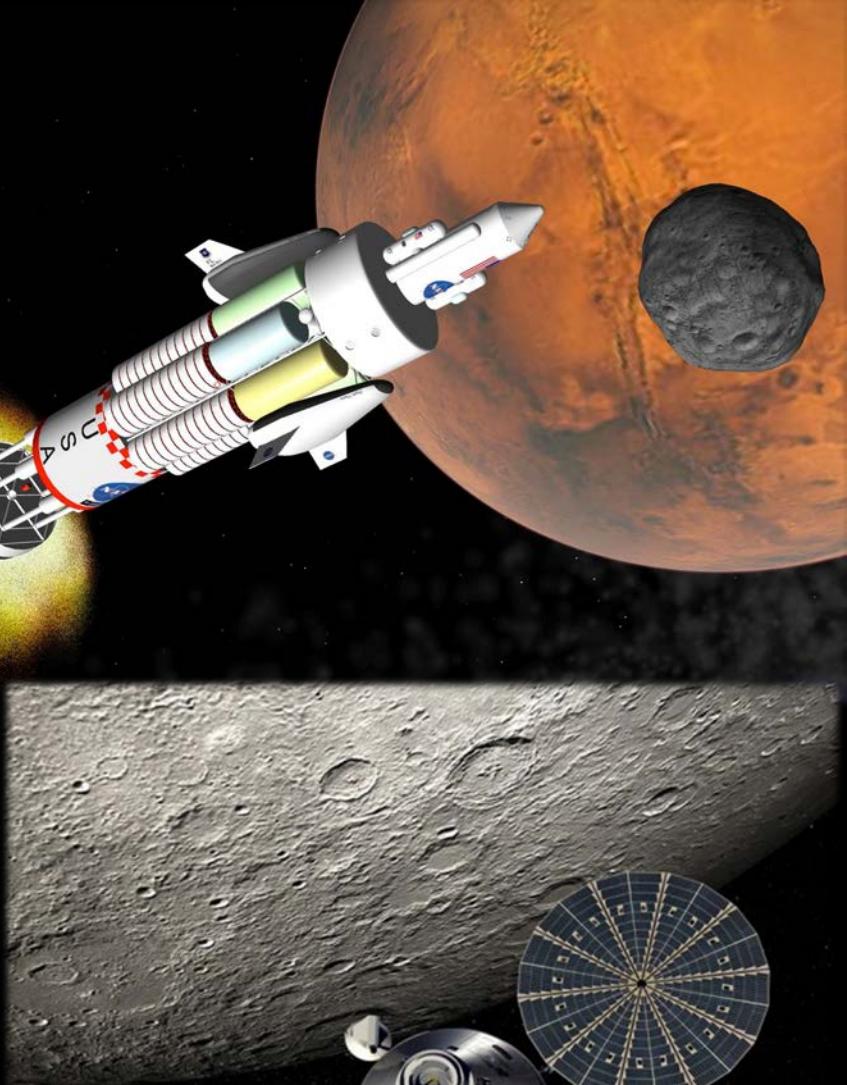
Cygnus arrival to ISS (12/08/15)



Final delivery (6 additional PFEs)



Future Destinations ...



*“The path from dreams to reality does exist.
May you have the vision to find it, the courage to get onto it,
and the perseverance to follow it.
Wishing you a great journey.”*



***Kalpana Chawla
STS-107 mission
Space Shuttle Columbia
January 2003***

"The STS-107 *Mist* crew" In Memoriam

